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A RAND NOTE

Possible Postwar Force Requirements for the
Persian Gulf: How Little Is Enough?

David A. Shlapak, Paul K. Davis

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Persian Gulf: How Little Is Enough?

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PREFACE

This Note presents a methodology developed in 1990 for estimating the forces that would be needed to defend Saudi Arabia and Kuwait in the aftermath of the crisis in the Persian Gulf. RAND created a simple, new requirements model for this work, and the Note describes the results of a preliminary analysis. Although the work was concluded in the second half of 1990, before the beginning of Operation *Desert Storm*, the analysis nevertheless retains much of its relevance.

The research was sponsored by the Commander in Chief, United States Central Command, and the Joint Staff. It was conducted in RAND's National Defense Research Institute (NDRI), a federally funded research and development center sponsored by the Office of the Secretary of Defense and the Joint Staff. Comments on this work are welcome, and should be directed either to the authors or to Charles T. Kelley, Director of RAND's International Security and Defense Strategy Program, which carried out the research.

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SUMMARY

The United States has for years stated that it considered the stability of the Persian Gulf area a vital national interest, and Washington's actions in the aftermath of the Iraqi invasion of Kuwait demonstrated the U.S. commitment to protecting its perceived stake in the region. Now, however, the United States must address itself to important questions about the future.

This study describes a methodology for estimating the force levels that would be needed to defend the Arabian peninsula in the postcrisis world, and it provides such an estimate. Because of the many uncertainties, we emphasize a parametric approach and employ extensive sensitivity analysis, varying assumptions about both policy and technical factors.[1]

Our approach emphasized simplicity and reasonable conservatism. We sought to use analytic techniques that could readily accommodate alternative assumptions, such as those that might be learned in the field. We did not assume worst-case scenarios, but neither did we base assessments on any of the special factors, such as night-fighting capability, that favor the United States in the current crisis. Instead, we focused on numbers-driven estimates consistent with attrition warfare, which would in many respects be a worst case for the United States.

We used two separate models in this work, relying primarily on a simple requirements model built using Microsoft Excel™ on a Macintosh personal computer. We performed literally hundreds of runs with this model, exploring the problem space and analyzing sensitivities. Because the model was completely parameterized, we had full and immediate control over its operation.

To complement the spreadsheet model, we used the RAND Strategy Assessment System (RSAS) for some more detailed analysis that better reflects geography, terrain, maneuver, and other aspects of combat ignored in the requirements model. This allowed us to calibrate (*not* validate) many key parameters of the simple model against RSAS outputs.

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[1]The work documented here was performed in fall and winter 1990, before the beginning of Operation *Desert Storm*. The postwar balance of military power in the Gulf differs radically from that we present here. Nonetheless, we believe that (1) the methodology serves as a general approach to first-order balance studies; (2) several of the key issues addressed in the Note were highlighted as *Desert Storm* unfolded; and (3) looked at as force requirements for defeating a numerically superior, well-armed opponent, the Note points the way toward more complete, future-oriented analyses of possible U.S. military involvements in the Middle East.

We also used the RSAS to study a handful of representative campaigns in enough detail to observe additional problems and issues.

Our analysis suggests that *about 3.5 effective equivalent divisions (EEDs; a U.S. armored division equals one EED) of heavy mechanized forces are needed to provide a good chance of successfully defending against an Iraqi attack on the Arabian peninsula.* If, for example, indigenous Saudi and Kuwaiti forces could be counted on to provide only about two of these EEDs, then three or four U.S. heavy brigades could make up the difference. While this estimate is based on preliminary analysis and is subject to confirmation, it implies that *a militarily useful U.S. presence in the region need not be as large as some have predicted.*

We also suggest that some 150–200 dedicated Air Force and Army aircraft for attack of ground forces must be available on D-day. This requirement could be met by augmenting regional forces with three U.S. attack helicopter battalions and a wing of A-10- or A-16-class aircraft.

These figures are subject to revision if and when better information on such issues as effective military frontage becomes available; nonetheless, we believe these numbers are reasonable first estimates. In addition to these forces, the United States would need to put in place a substantial support echelon and such other force elements as:

- Additional air forces, numbering perhaps in the hundreds, to allow Blue (U.S. and partners) ground-attack aircraft relatively unmolested access to the battlefield and Red's (Iraq's) shallow rear.
- An antitactical ballistic missile (ATBM) system able to defend air bases and other key points against attack.

Our limited work with the RSAS also leads us to three comments:

- To enhance their ability to operate independently across long distances, U.S. ground units deployed in Arabia as part of the D-day force should be configured more like armored cavalry regiments or independent brigades than divisions.
- Air power is vital to Blue's success in both models used in this study. To ensure its effectiveness, Blue must have the ability to operate in the presence of dispersed air-defense weapons that survive a generally successful air-defense suppression campaign. Innovations in munitions, tactics, and countermeasures may have higher payoffs than procurement of new platforms in this regard.

We also suggest a role for focused diplomacy and possibly arms control in increasing the stability of the Gulf region. Effective embargoes on the sale of advanced air-defense weapons to Iraq, for example, may contribute effectively to this end. A credible, clearly stated policy against threatening force deployments in southern Iraq could greatly improve defense prospects and reduce the need for in-place U.S. forces. Defensive preparations, such as barriers, are also a possibility, although their political feasibility is questionable. Finally, friendly Gulf states, such as Saudi Arabia and Kuwait, probably will have to maintain larger and higher-quality armed forces.

We have identified the following two areas where further analysis could profitably be undertaken:

- First, *a study is needed of near-term Gulf strategy options for the United States.* In particular, a close look needs to be taken at the shape of the regional balance of power in the aftermath of the 1990-1991 crisis. How can the United States act to stabilize the military balance without disrupting the equally fragile political equilibrium of the region?

- *Second, a more detailed follow-on to the current study is called for.* Using the work reported on here as a starting point and relying more heavily on operational-level analysis, it would examine the options available for ensuring a strong defensive posture in Arabia, including trade-offs between
  — Air vs. ground forces
  — In-place forces vs. prepositioning ashore and/or afloat vs. "fast-deploying" U.S.-based forces
  — U.S. vs. indigenous vs. outside Arab forces
  — Defensive strategies

The second study would also encompass an assessment of operational arms control measures, such as the red-line strategy discussed above.

ACKNOWLEDGMENTS

CONTENTS

FIGURES

TABLES

I. INTRODUCTION

Since the end of the Iran-Iraq war in 1988, an imbalance of power (summarized in Table 1) has existed in the Persian Gulf region. Saddam Hussein's war machine, fueled by petrodollars and supplied by both East and West, had made Iraq the preeminent military power in the area. On 2 August 1990, this machine was unleashed on tiny Kuwait, which was virtually defenseless in the face of the onslaught. The consequences of this aggression will be felt throughout the world for years to come.

The United States has for years stated that it considered the stability of the Persian Gulf area a vital national interest, and Washington's actions in the aftermath of the invasion of Kuwait demonstrated the U.S. commitment to protecting its perceived stake in the region. Now, the United States must address itself to important questions about the future.

ENSURING THE FUTURE STABILITY OF THE GULF

Obviously, the future state of the Gulf is strongly conditioned by the history being written today. Nonetheless, we can at least outline some key aspects of the future security environment.

Regardless of how the current crisis plays out, the United States will retain a vital interest in the region. It is also likely that Iraq will remain the predominant military power in the region and will retain some capability to wage aggressive war against its neighbors to the south. To the extent, then, that the United States seeks to avoid a replay of recent events, it must explore policy options to prevent or, if necessary, decisively defeat Iraqi attacks on Kuwait and/or Saudi Arabia. The U.S. response to this challenge will include diplomatic, economic, and military arrangements; this Note begins to address the postcrisis balance of military power in the Gulf.[1]

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[1]The work documented here was performed in fall and winter 1990, before the beginning of Operation *Desert Storm*. The postwar balance of military power in the Gulf differs radically from that we present here. None·heless, we believe that (1) the methodology serves as a general approach to first-order balance studies; (2) several of the key issues that it addresses, including the possibility for broad off-road maneuver in the Arabian desert and the nonattrition effects of air power on the battlefield, were highlighted as *Desert Storm* unfolded; and (3) looked at as force requirements for defeating a numerically superior, well-armed opponent, the Note points the way toward more complete, future-oriented analyses of possible U.S. military involvements in the Middle East.

Table 1

Comparative Force Strengths in the Persian Gulf, June 1990

Country	Medium Tanks	APC/ IFV	Artillery	Combat Aircraft	Armed Helicopters
Iraq	5500	7500	3500	689	159
Kuwait	245	705	72	35	18
Saudi Arabia	550	1780	475	189	20
Iran	500	650	800	185	109
Other GCC	248	849	2C3	19.)	51

NOTE: APC = armored personnel carrier; IFV = infantry fighting vehicle. "Other GCC" (Gulf Cooperation Council) includes forces of Bahrain, Oman, Qatar, and the United Arab Emirates. *The Military Balance 1990-1991*, The International Institute for Strategic Studies, 1991, pp. 100-121.

The study's subtitle, "How Little Is Enough?" reflects our view that both indigenous armed forces and foreign troop contingents permanently stationed in the Gulf are profoundly constrained. The limitations are demographic, cultural, and political, and victory in any war with Iraq will neither sweep them away nor render them moot. Thus, the issue becomes precisely how little is enough—not just to pose a modest deterrent to Iraq, but to provide a credible defense should deterrence fail.

ANALYTIC APPROACH

The purpose of this study, then, was to provide a methodology for estimating the force levels that would be needed to defend the Arabian peninsula in the postcrisis world. Because of the many uncertainties, we emphasized a parametric approach and employed extensive sensitivity analysis, varying assumptions about both policy (e.g., residual force levels, deployment capabilities) and technical factors (e.g., intensity of combat, effectiveness of air power).

Our approach emphasized simplicity and reasonable conservatism. We sought to use analytic techniques that could readily accommodate alternative assumptions, such as those that might be learned in the field. We did not assume worst-case threats, but neither did we base assessments on any of the special factors, such as night-fighting capability, that favor the United States in the current crisis. Instead, we focused on numbers-driven estimates consistent with attrition warfare. *This Note does not represent operational analysis*; we cannot emphasize this point enough. It is a political-military requirements analysis that can serve as a starting point for more in-depth work. We understand, for example, that the maneuver of both forces and fires would play a dominant role on the battlefield we attempt to

describe and that U.S. and allied forces may have significant advantages in these areas that can compensate for some numerical weakness. However, without some minimum level of forces, defender success would depend on a degree of maneuver superiority that it would be imprudent to assume. This study attempts to define that minimum force level.

Clearly, the United States would almost never *choose* to fight a war of attrition, in the Persian Gulf or anywhere else, nor should our approach be taken as an endorsement of employing U.S. forces in this way. The powerful advantages U.S. forces possess in training, leadership, and technology can best be exploited on a fluid, three-dimensional battlefield, such as that envisioned in the U.S. Army's AirLand Battle doctrine. Our decision to use a different paradigm does not mean that we overlooked this doctrine; indeed, quite the opposite—it was a deliberate choice conditioned by the purpose of the analysis. We intended this requirements study to provide a conservative, almost "worst-case" assessment of aggregated force requirements. In considering how to do this, we concluded that an attrition "slugfest" of the sort we depict was the right way to structure the analysis.

TWO MODELS USED

Given our objectives, we used two separate models. We relied primarily on a simple requirements model built using Microsoft Excel™ on an Apple Macintosh personal computer. We performed literally hundreds of runs with this model, exploring the problem space and analyzing sensitivities. Because the model was completely parameterized, we had full and immediate control over its operation.

The simple model had many advantages, but two stood out. First, many combat models are sufficiently complex that an analyst's attention may focus more on the tool than on the problem. We avoided this potential pitfall by using a highly simplified and aggregated model. In essence, we used the spreadsheet as a mind-clearing stratagem.

Second, we sought to provide insight into policy-level issues, not military-tactical ones. We therefore wanted to pitch the analysis to a somewhat higher level and to present it in a manner accessible to broad audiences. The spreadsheet model is highly transparent and quickly understandable by anyone, regardless of familiarity with models.

To complement the spreadsheet model, we used the RAND Strategy Assessment System (RSAS) for some more detailed analysis that better reflects considerations of geography, terrain, maneuver, and other aspects of combat ignored in the requirements model. This allowed us to calibrate (*not* validate) many key parameters of the simple model against RSAS outputs. We also used the RSAS to study a handful of representative campaigns in enough detail to observe additional problems and issues.

Section II describes the spreadsheet model in some detail, and presents our principal study results. Section III discusses our observations from the RSAS runs undertaken for this study. Finally, Section IV recaps our conclusions and makes suggestions for further research.

II. A SIMPLIFIED REQUIREMENTS MODEL: DESCRIPTION AND RESULTS

In thinking about the spreadsheet requirements model, we must note again that it is a tool for aggregated defense planning as *part* of the force planning process; it is not meant to substitute for more complex and detailed operational analysis. It is deliberately simple and straightforward. Its value lies in highlighting, and allowing the analyst to concentrate on, the factors that tend to drive results in more sophisticated models.

KEY ASSUMPTIONS AND VARIABLES OF THE REQUIREMENTS MODEL

As stated above, the requirements model depicts warfare as a pure attrition slugfest from the theater perspective.[1] The model adjudicates a Blue or Red victory according to the following criteria:[2]

- Blue wins by maintaining a minimum number of forces on line while
  - Holding one-third of available force in reserve *and*
  - Attriting Red's total force to a user-specified breakpoint.
- Red wins by keeping its attrition below its breakpoint while
  - Reducing Blue's on-line force below the user-specified minimum *or*
  - Attriting Blue's total force to a user-specified breakpoint.

In addition to the win/lose criterion, we also used force ratio and exchange ratio as measures of merit. The latter is particularly important—a higher Red-to-Blue exchange ratio means a quicker victory with fewer defender losses.

The model assumes that Red tactical air (tacair) is suppressed to the point that it has no impact on the battlefield. That is, Blue has default air superiority over the battlefield and into Red's shallow rear. The model does *not* assume that Blue air has total freedom of action over Iraq itself.

Blue's tacair is, however, applied to the land battle, where it has two effects.[3] First, of course, it destroys enemy armored fighting vehicles (AFVs). Second, we postulate a

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[1] Given current and projected future capabilities, the lack of maneuver in the model works to Iraq's advantage. This is part of what we meant when we said that we tried to be "reasonably conservative."

[2] In this Note, "Blue" refers to the United States and its partners defending Kuwait and Saudi Arabia; "Red" refers to Iraq.

[3] In this study, Blue tacair includes both fixed- and rotary-wing assets. This diverges somewhat from the term's traditional usage.

disruptive effect on both maneuver and logistics; we reflect this in the model by reducing within limits the effective Red-to-Blue forward line of troops (FLOT) force ratio in proportion to Blue's air power. The purpose here is to explore parametrically effects of air power that are often discussed, generally accepted as real, but rarely treated analytically. Our model is admittedly crude; we believe, however, that it is on the whole more realistic than assuming, as most analyses do, that air power has no nonattrition impact on the battlefield.

Table 2 lists the parameters of the spreadsheet requirements model along with the baseline values assigned to each. We review them below in somewhat greater detail.

Bo is the D-day Blue ground force level, expressed in effective equivalent divisions (EEDs). As used here, "effective" accounts for considerations of force quality, including training level, leadership, doctrine. and so forth. This is important, as our notional Blue force consists of U.S., Saudi, Kuwaiti, and other troops of varying quality.

The equipment holdings of a Kuwaiti mechanized brigade, for example, might be quite similar to those of its U.S. counterpart; this means that the equivalent division (ED) score of the two brigades would be nearly equal. However, the common wisdom regarding Saudi and Kuwaiti forces has been that they are not nearly as combat-effective as their unit equipment might indicate. Thus, we measure strength in EEDs to allow discounting of forces for perceived qualitative inadequacies.

For purposes of this study, we assume that friendly Arab forces would be half as effective as their equipment holdings; that is, one Kuwaiti or Saudi ED equals one-half an EED.[4] U.S. and Iraqi forces fight at full strength; i.e., one ED equals one EED. This seems to overestimate the capability of the Iraqis to conduct sustained, deep offensive operations against a well-equipped enemy possessing at least local air superiority; however, the Iraqi force level is simply a parameter in any case, as we discuss below.

Bo also serves as the primary dependent variable in the study. That is, we systematically varied the other model parameters and solved for the number of Blue EEDs needed on D-day for a Blue victory.

Ao is the number of dedicated close air support (CAS) and battlefield air interdiction (BAI) aircraft available to Blue on D-day; recall that these include both fixed-wing aircraft and attack helicopters.

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[4] The "common wisdom" cited here may need to be revised, based on the outcome of the Gulf war. Our model could easily accommodate such a change.

Table 2

Key Variables of the Requirements Model

Parameter	Definition	Baseline value
Bo	D-day Blue force level	2-5 EEDs
Ao	D-day Blue CAS/BAI aircraft	0-300
Ro	Total Red force level	14 EEDs
dep	Blue deployment rate for ground forces	0.1 EEDs/day
Tog	Date Blue ground reinforcement begins	Day 5
adep	Blue deployment rate for CAS/BAI aircraft	24 aircraft/day
Amax	Maximum number of Blue CAS/BAI aircraft	300
Toair	Date Blue air reinforcement begins	Day 2
Terr	Defender's terrain enhancement factor	1.0
LRo	Defender ED loss rate at 3:1 force ratio	10%/ED/day
ER	Exchange ratio at 3:1 force ratio	2:1
K	AFV kills per air-to-ground sortie	1.0
Acrit	Number of sorties per on-line enemy EED to maximize countermaneuver effect	100
Mmin	Maximum reduction in FLOT force ratio due to air effects	50%
Pa	Attacker's attrition breakpoint	40%
Pd	Defender's attrition breakpoint	50%
Na	Maximum attacking EEDs allowed on-line	4.5
Nd	Minimum defending EEDs required on-line	1.125

R_o is the size of the Red force brought to bear against Kuwait and Saudi Arabia. The 14 EEDs we used as a baseline could correspond to any of many combinations, such as 20 well-trained, well-equipped heavy divisions, or a larger number of poorer formations. Of course, before the Gulf war Iraq had many more than 14 EEDs in its force structure. However, many of these consisted of leg infantry units of questionable quality with little capability for offensive operations or effective defense against an armored opponent. It is also assumed that a sizable force is devoted to securing Baghdad's borders with Iran, Syria, and Turkey.

Blue deployment rates and the arrival times for air and ground reinforcements are based on deployment rates observed with current U.S. capabilities in some Southwest Asia scenarios simulated in the RSAS; they assume relatively little use of strategic warning. Air reinforcement notionally includes not only new assets flowing into theater but also the reassignment of squadrons to CAS and BAI missions.

As a baseline, we assume no barriers or other special defensive preparations.

LRo is the daily equipment loss rate per engaged defending EED. Our baseline value of 10 percent (representing about two percent in personnel terms) is, historically speaking, on the average-to-high side for moderately intensive armored combat.[5] LRo varies with force ratio; 10 percent occurs at 3:1.

A defender-favorable exchange ratio of 2:1 at a FLOT force ratio of 3:1 (and varying inversely with force ratio) is reasonable; it is more conservative than the 3:1 exchange ratio often seen in simulations. We use the lower number in part because (1) the quality of defensive preparations might not be as high as that expected in Europe or Korea and (2) combat in Arabia might be more maneuver-oriented— resulting in a higher proportion of meeting engagements.

The Blue air-to-ground kill rate of one AFV per sortie is based on various RAND and government studies for attacks on targets moving in the open. It is quite high by historical standards, but much lower than the kill rates potentially achievable in a "duck-shoot" situation.[6]

Acrit and Mmin govern the postulated countermaneuver and counterlogistics effects of CAS and BAI. The model reduces the effective force ratio in proportion to the number of Blue air-to-ground sorties per on-line Red EED until a maximum effect is achieved when Acrit sorties are applied to each engaged Red ED.[7] At this point, the effective force ratio equals Mmin multiplied by the nominal force ratio. The numbers used as a baseline here are quite soft. It remains to be determined what mix of CAS and BAI aircraft, deep interdiction capability, and attack helicopters would work best for disrupting enemy operations at the front.[8] Some believe CAS and BAI can seriously impair tactical maneuver, thereby reducing enemy effectiveness; others maintain that isolating the battlefield through attacks on reserve forces and logistics would be the key. We do not attempt to resolve these questions here, but we see a need to incorporate some aspects of these nonattrition effects in our analytic scheme.

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[5] Higher loss rates are sometimes observed in simulations, often because the probability-of-kill (Pk) numbers that drive attrition in such models are derived from proving-ground tests. Such Pk's are typically much higher than those actually attained in combat.

[6] Anecdotal evidence from *Desert Storm* suggests that Iraqi vehicles moving in the open were highly vulnerable to air attack.

[7] Although the model's inputs are in terms of CAS and BAI *aircraft*, its calculations involve sortie. We assume two sorties per aircraft per day across the fleet.

[8] Note that specialized, long-range artillery and missile fires, such as tactical missile system (TACMS) or naval gun support, could be incorporated in the model as "sortie-equivalents."

The breaking points Pa and Pd are expressed as percentages across the entire deployed force, not individual divisions. Thus, assuming our baseline Iraqi force of 14 EEDs, the model assesses Red as incapable of sustaining an attack once about 5.6 EEDs are destroyed.

Na and Nd represent two very important parameters. Because these two variables drive the study's results, we describe their origins and import immediately below.

How Many Attacking Divisions Can the Iraqis Keep On-Line?

Figure 1 is a highly simplified picture of the military geography of southern Iraq, Kuwait, and eastern Saudi Arabia. Of the three main attack axes into Saudi Arabia, only one, represented by the central arrow toward Hofuf, can support a multidivisional front along most of its length.[9] Here are broad, open spaces, ideal for wide-ranging operations by large mechanized forces.

Two classes of limitations, however, restrict the number of Iraqi units that could operate even in this most suitable terrain:

- The Iraqi logistics infrastructure has no experience supporting large-scale combat operations some hundreds of kilometers into enemy territory; Blue air superiority over much of the area Iraqi convoys would have to traverse would further compound the difficulty.
- While tracked combat vehicles could potentially roam far from roads and tracks, wheeled logistics trucks would be more closely tied to them.

Thus, while Iraqi armor could exploit *tactical* mobility, *operationally* they would be more restricted. Taking these factors into account, and relying on a first-order terrain analysis along with informal estimates provided to us, we assumed that about 4.5 EEDs of Iraqi forces could be employed on-line at any given time across all three avenues of approach combined. This might correspond to about six to seven divisions if they were of high fighting quality.

How Many EEDs Must Blue Keep On-Line?

Nd is the number of defender EEDs needed on-line to maintain cohesion; it depends on the density of forces needed for successful defense and the frontage being defended.

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[9] This assessment is based on map studies, rather than on walking the terrain. However, it has been informally confirmed by several individuals familiar with the areas.
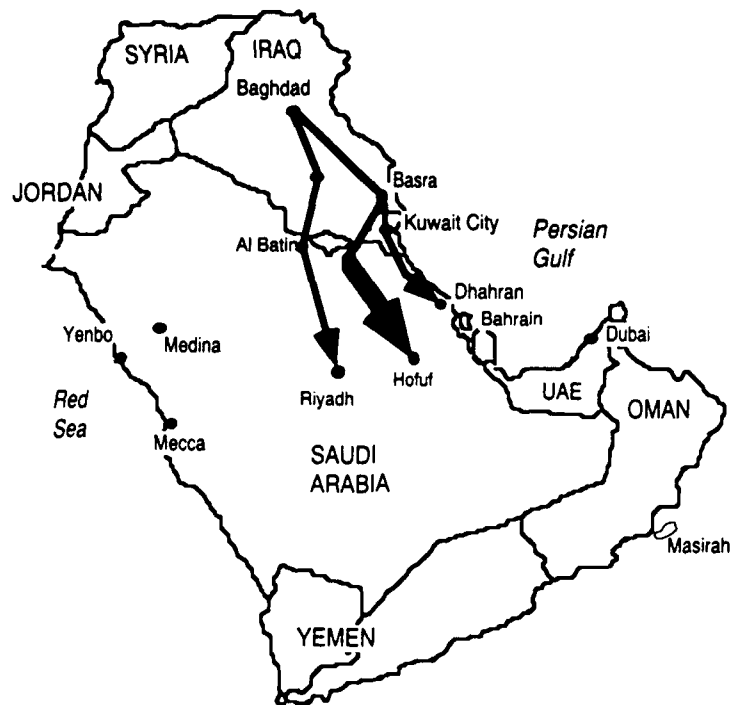
Fig. 1—Simplified Military Geography of the Persian Gulf Area

Assuming that each of the 4.5 attacking Red EEDs masses across 10 km, Blue must defend 45 km. We assume that a Blue EED can cover 40 km if:

- The line is allowed to slip; that is, Blue does not attempt to mount a rigid forward defense.
- Blue has air superiority over the battle line.
- Blue retains a substantial operational reserve (one-third of his total force).

The first assumption merits explanation. We noted earlier that our analysis assumes attrition-type warfare, even though the United States would actually conduct more wide-open, maneuver-oriented operations. Similarly, we understand that a defensive battle in Saudi Arabia could best be fought by trading large amounts of territory for time, all the while pummeling the advancing Iraqi forces with air power.[10] Our model, however, does not incorporate any representation of terrain loss or FLOT movement; we represent this

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[10] We are indebted to William M. Hix for reminding us that current U.S. doctrine would call for just such a nonlinear defense in these circumstances.

willingness to tolerate retrograde movement by reducing the size of Blue forces needed on "the front." Put differently, had we intended to represent a linear forward defense of Saudi Arabia, we would have required a much higher Blue force density and assumed a larger military frontage.

From these assumptions, we calculate that one-and-one-eighth Blue EEDs are required at the front at all times.[11] A notional baseline laydown of Red and Blue forces is shown in Fig. 2.

We emphasize the importance of these terrain factors; analysts familiar with the terrain should assess them. Given our uncertainties in this regard, we varied the values of these parameters extensively.

RESULTS FROM THE REQUIREMENTS MODEL

Base Case Results

Figure 3 shows the results of our base case.[12] Each point on the line represents a minimum Blue force posture that, when input to the model, results in a Blue victory. Thus, on this and the similar graphs that follow, any Blue force configuration on or to the right of the line represents a winning solution for the defender; any posture to the left of the line results in defeat.

Figure 3 suggests that a force of about 2.25 EEDs and 25 CAS/BAI aircraft could win for Blue. A glance at the combined precrisis orders of battle for Kuwait and Saudi Arabia might indicate that indigenous forces could fill this requirement; on the basis of equipment alone, they add up to almost five EDs.[13] However, the fighting capability of these troops probably does not match the quality of their equipment—recall that our unit of ground forces is the *effective* ED, which takes into account training, leadership, and so forth. Also, the local air forces lack the equipment, training, and doctrine to adequately suppress either the Iraqi air force or ground-based Red air defenses. In sum, reliance on local forces alone would be very risky unless their capacity increased substantially, a process that would take several years.

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[11] Remembering that one-third of all defender forces are in reserve at any time, this means that, using baseline values, Blue must always have at least 1.7 EEDs available.

[12] These graphs seem to suggest a relatively low degree of substitutability between air and ground forces. We address this issue below in this section, under the heading "The Value of Air Power."

[13] ED strength based on *The Military Balance 1989-1990*, International Institute for Strategic Studies, Brassey's, London, 1989.
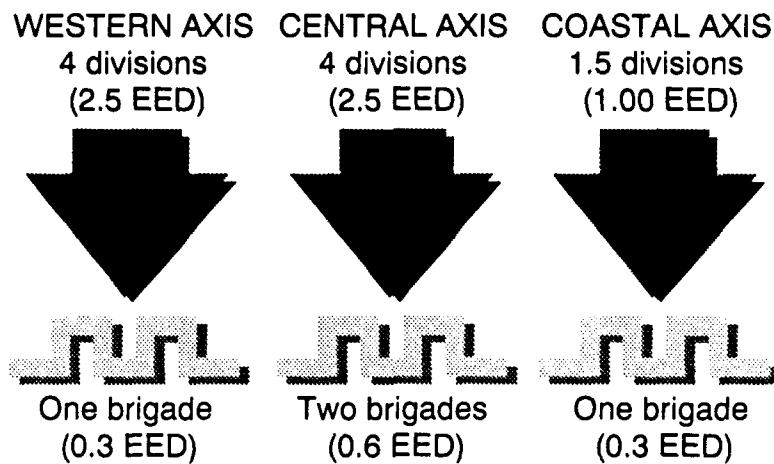
WESTERN AXIS   CENTRAL AXIS   COASTAL AXIS
4 divisions   4 divisions   1.5 divisions
(2.5 EED)   (2.5 EED)   (1.00 EED)

One brigade   Two brigades   One brigade
(0.3 EED)   (0.6 EED)   (0.3 EED)

Fig. 2—Notional Baseline Force Laydown

Number of
Blue CAS/BAI
aircraft on
D-day

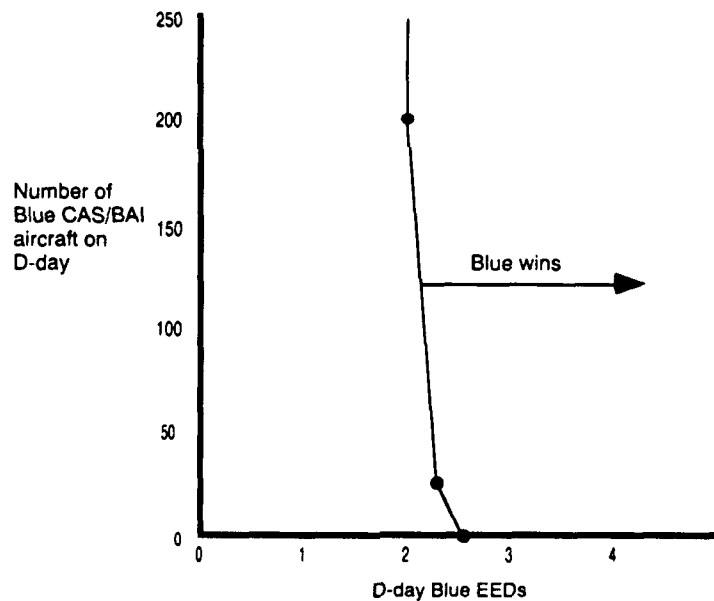Blue wins →

D-day Blue EEDs

Fig. 3—Base Case Results

The base case was just a starting point, of course. Our approach revolved around
extensive sensitivity analysis across all of the model's parameters. Hundreds
of runs were performed to determine the dominant sensitivities. Four main drivers emerged:

- Defender's attrition breaking point (Pd)
- Defender's loss rate (LRo)
- Minimum defending EEDs on-line (Nd)
- Maximum attacking EEDs on-line (Na).

We will look at each of these in greater detail.

Defender's Attrition Breaking Point

Historically, units have collapsed at widely varying levels of attrition—some have lost cohesion after taking only a few casualties, while others have fought to the last man.   In this study, we tested the sensitivity of results to changes in both the attacker's and defender's ability to take losses.

Figure 4 shows the sensitivity of Blue's force requirements to a significant reduction in the defender's ability to absorb casualties. The left-hand line is the same baseline graph seen in Fig. 3, which assumes that Blue forces can be reduced 50 percent before becoming incohesive. The second line shows results if the defender can take only 25 percent losses before breaking. The dotted line shows that hedging against this uncertainty increases Blue's requirements to 2.25 EEDs and 100 CAS/BAI aircraft.[14] A unit's breaking point is probably related more to the quality of its personnel than to the caliber or quantity of its equipment; hence, the sensitivity of Blue requirements to this factor is another reason for being cautious and conservative in assessing the quality of regional forces.

Our results show that *increasing* the defender's ability to take losses beyond 50 percent does not decrease force requirements; this is because at low force levels, the density criterion for Blue success dominates total losses.   In the neighborhood of the baseline case, results are not sensitive to assumptions about the attacker's breaking point.

Defender's Loss Rate

Figure 5 shows the effects of changing assumptions about the intensity of combat as reflected in the defender's loss rate.   Once again, the far left line shows our baseline results, which used a 10 percent loss rate per EED per day.   The other lines show outcomes when we increased this rate to 30 percent in steps of 10 percent.

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[14] In this figure and in those that follow, the dashed lines indicate one of many points along the curve of adequacy. The point chosen generally is the one that minimizes the ground-force requirement, which we assume to be the most troublesome politically.
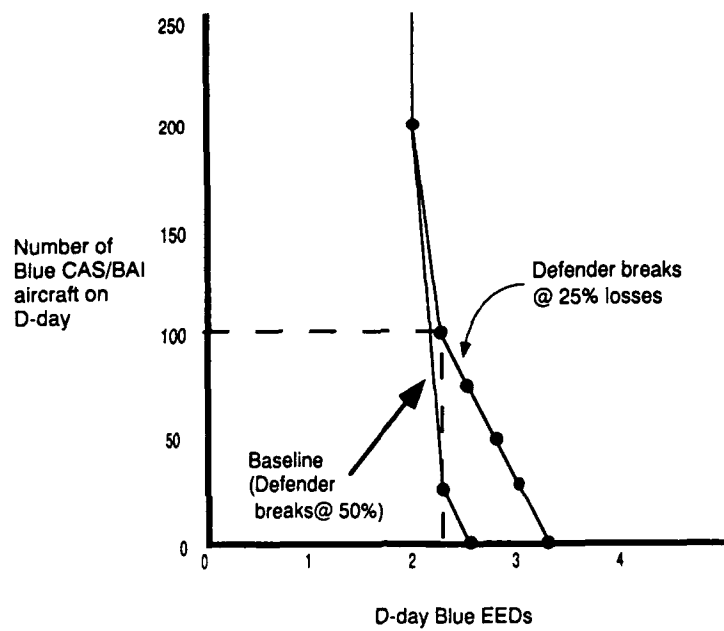
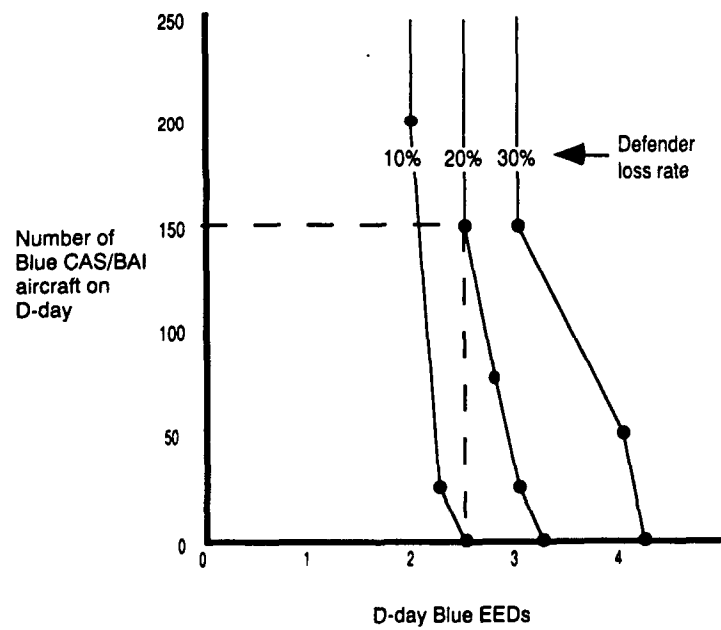**Fig. 4—Sensitivity to Changes in Pd**

Fig. 5—Sensitivity to Changes in LRo

Our concern for this particular sensitivity was driven by a perception that modern desert warfare might be unprecedentedly lethal. Historically, smaller units have sustained higher loss rates than larger ones because a greater fraction of the smaller force is actually engaged. According to Trevor Dupuy, for example, casualties for engaged brigades are typically about twice as high as those suffered by division-sized formations.[15] Defending with small forces, Blue might frequently find itself in brigade-vs.-division engagements.

Modern weapons and munitions, moreover, may be more deadly than their predecessors, particularly against moving targets on a clear day in the desert. Finally, a desert war of maneuver would involve a larger number of meeting engagements, in which the defender would likely absorb higher losses than he would if occupying dug-in positions. It therefore seems prudent to hedge against unexpectedly high loss rates; posturing against a 20 percent loss rate appears to be adequate in this regard.

A Blue D-day posture of 2.5 EEDs and 150 ground support aircraft "wins" in the requirements model even if we double our assumed defender loss rate to 20 percent per EED per day. In our view, this buffers the Blue force posture against reasonable uncertainties in intensity.

Note that even our baseline assumption of equipment losses of ten percent per day is high when applied across a total force for a campaign of many days, as it is in our model. Thus, while our recommended force size does not protect Blue against absolute worst-case assumptions about attrition, it represents a fairly robust posture by all historical standards.

Minimum Defending EEDs On-Line

Two parameters drive the minimum number of defending EEDs required on-line: the frontage a single EED can defend and the number of attacking EEDs allowed. Here, we discuss the first of these factors.

According to our baseline estimate, a Blue EED can effectively defend 40 km of front if Blue depends on air power and maneuver capability to protect against flanking operations. This estimate is based on European numbers intuitively modified to account for allied air superiority and other factors unique to the current analysis. Figure 6 shows how force requirements change if we assume that an EED can hold no more than 30 km without making itself liable to breakthrough. We see that 2.75 EEDs and 50 CAS/BAI aircraft are needed on D-day to protect against this uncertainty.

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[15] T. N. Dupuy, *Understanding War,* Paragon House, New York, 1987, p. 188.
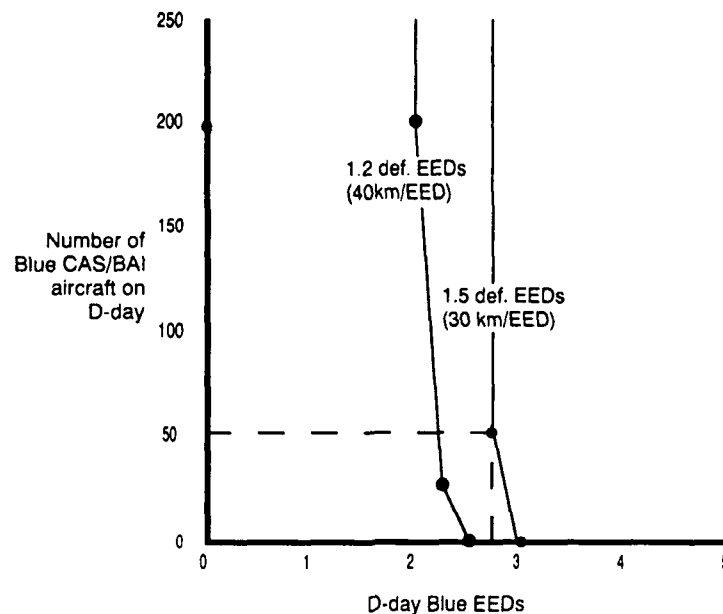
Fig. 6—Sensitivity to Nd

Maximum Attacking EEDs On-Line

As discussed above, the requirements model assumes that considerations of terrain, logistics, command, and vulnerability would limit the forces that Iraq could maintain in combat at any given time. Our base case allows Red to fight 4.5 EEDs, or about seven division flags, at once. Figure 7 shows how requirements change when the attacking force is allowed to grow to six EEDs, or roughly nine divisions. Using baseline values for all other parameters, this change drives the size of the necessary Blue force up to 2.75 EEDs and 200 ground-support aircraft.

Combining Uncertainties About Military Width

We feel least comfortable with the manner in which our model deals with these two related issues of allowed attacker and required defender force sizes. Our knowledge of the terrain in question, the likely capabilities of Iraq to sustain fast-paced offensive operations, and the ability of Blue air power to cover flanks and channel enemy attacks into defended areas are all highly uncertain. We show in Fig. 8, therefore, what happens to force requirements if we combine a larger attacking force (six EEDs) with the need for a denser defensive posture (30 km coverage per Blue EED). The graph suggests that a D-day force of 3.5 EEDs and 200 CAS/BAI aircraft is adequate to hedge against these combined uncertainties.
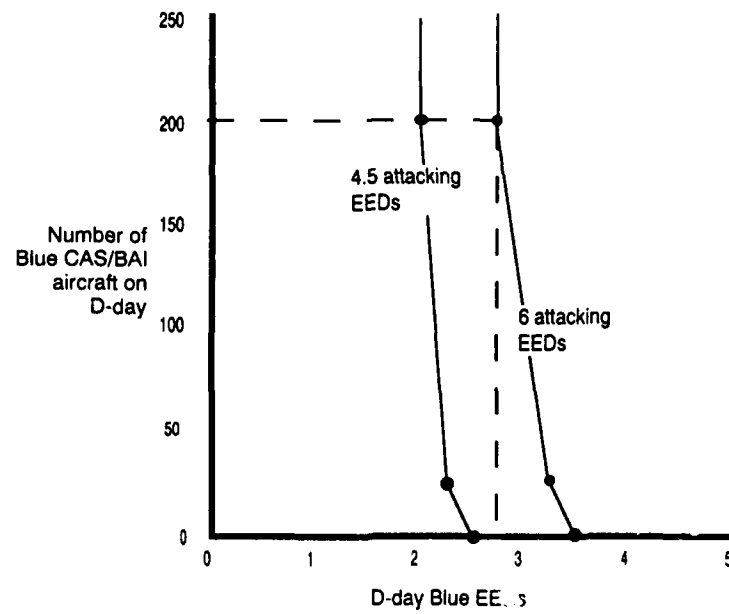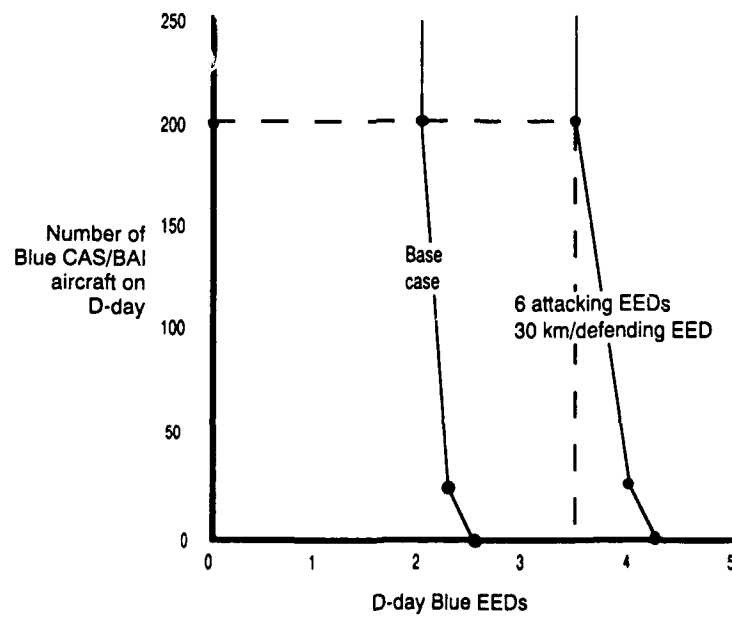
Fig. 7—Sensitivity to Na

Fig. 8—Combined Sensitivity to Nd and Na

THE VALUE OF AIR POWER

Figures 3–8 suggest the relatively small substitutability between air and ground forces. This conclusion seems counterintuitive, particularly when one considers that we are trying to represent a relatively mobile battle in which the flexibility and lethality of air power would be particularly useful.

To understand this seeming paradox, keep in mind the low levels of ground forces involved in our scenarios. With only three to 3.5 EEDs available, a theater commander would be imprudent, we believe, to trade any sizable portion of his ground forces for additional air power, as to do so would be tantamount to relying on air to win the day. We accept that, at force levels higher than those discussed in this Note, the marginal trade-offs between air and ground forces could well be fluid. However, around the minimum force sizes under scrutiny here, the relative stiffness of the ground force requirement does not seem unreasonable.

We were surprised to find the requirements model relatively insensitive to variations in the effectiveness of Blue's tacair. That is, varying killing power of air (changing K, the number of AFVs killed per sortie) up or down neither increased nor decreased requirements significantly. Nor did changing air's countermaneuver and counterlogistics effects (by varying Mmin) alter them. However, air did have a critical role in shaping the battlefield.

Consider, for example, the level of allied casualties. In our base case, Blue must destroy about 5.6 enemy EEDs to "win." If Blue maintains a 2:1 exchange ratio while doing so, he will incur 2.8 EEDs in losses; this could translate into 10,000 friendly casualties. The killing power of tacair, however, can help Blue achieve much better exchange ratios of 5:1 or even higher, which result in much smaller losses. Figure 9 shows the effects of air power on exchange ratio in the requirements model.

Table 3 makes the same point in a somewhat different way. Using base case values for all combat parameters, it shows how war outcome varies given different initial amounts of air power:

- In the first case, Blue applies no tacair to the battlefield. To win requires 4.0 EEDs on D-day; the war ends in a defender victory on day 13 after Blue has lost 1.9 EDs.
- In the second case, Blue has 100 CAS and BAI aircraft (200 sorties) available every day. His D-day ground force requirement drops by a full EED, he wins a day earlier, and he reduces his losses by over 25 percent.
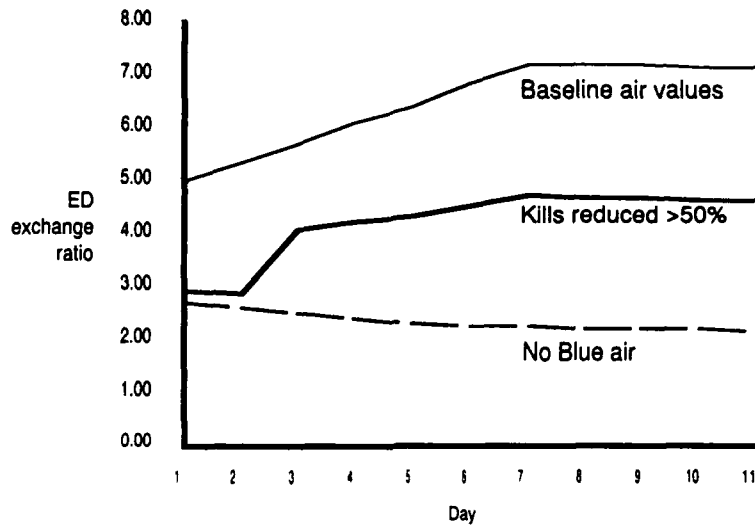
Fig. 9—Effects of Tacair on Exchange Ratio

Table 3

A Quicker, Cheaper Victory with Air Power

Blue D-day A-G A/C	Air reinforce- ment	Day Blue wins	Blue D-day EEDs req'd	Blue losses (EDs)
0	No	13	4.00	1.9
100	No	12	3.00	1.4
100	Yes	10	2.25	0.9
200	Yes	8	2.25	0.6

NOTE: A-G A/C = air-to-ground attack aircraft.

- Case 3 employs the same 100 ground attack aircraft on D-day with standard assumptions about air reinforcement.[16] The defender needs only 2.25 EEDs on D-day, wins on day 10, and suffers less than an ED in losses.
- Finally, case 4 allows Blue 200 CAS and BAI aircraft on D-day and reinforces them as in case 3. Blue still needs 2.25 EEDs on D-day, but he wins on day 8, and his losses drop to only 0.6 EDs.

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[16] One additional squadron each day to a maximum of 300 aircraft.

Thus, while air power may not reduce the marginal requirements for ground forces at the low troop levels examined here, *it has a profound effect on how quickly and cheaply victory is obtained.*

SUMMATION

The requirements model showed special sensitivity to four factors: defender's attrition breaking point, defender loss rate, required number of defender EEDs on the FLOT, and allowed number of attacking EEDs on the FLOT. Each of these drives up the size of Blue forces needed to successfully defend against an Iraqi attack. In particular, we are concerned about the last two parameters, which represent a combination of assumptions about terrain, force quality, and so forth. Therefore, we suggest that the minimum force posture that hedges against reasonable uncertainties in these areas—3.5 EEDs and 200 CAS/BAI aircraft—be used as a starting point for more detailed and operationally oriented assessments of force requirements.

III. SUPPLEMENTARY ANALYSIS WITH AN OPERATIONAL-LEVEL MODEL

THE RAND STRATEGY ASSESSMENT SYSTEM

As mentioned in the Introduction, to supplement our work with the requirements model we conducted some operational-level analysis using the RAND Strategy Assessment System.[1] Our work used the RSAS CAMPAIGN-ALT model of the Arabian peninsula and vicinity. CAMPAIGN-ALT is a highly flexible combat model which uses a network-like representation of a theater, rather than the more traditional piston axes.[2]

- Terrain effects on movement, massing, and defensibility are explicitly incorporated, as is situational scoring of forces.
- Units can be represented as specific entities (the U.S. 1st Cavalry Division), or as generic types (an Iraqi Republican Guards armored division). In this study, we used specific friendly units and generic Iraqi ones.
- Operational maneuver, such as flanking and breakthrough operations, is represented.
- A simple representation of theater logistics is included.

In sum, the RSAS is a complex, but flexible and informative, system. We used it early in our work to provide some baseline inputs to the requirements model and later to begin adding some operational flavor to the analysis.

To the former end, we used terrain data from the RSAS to provide first-order estimates of the key parameters Na (number of attacking EEDs allowed on-line) and Nd (number of defending EEDs required on-line). Operational factors—such as defender loss rate, exchange ratio, and the number of ground-attack sorties allowed per day—were also drawn from comparable outputs of the RSAS. Finally, we checked to ensure that the relative weight of air power between the two models was roughly the same. That is, we verified that tacair was responsible for approximately the same proportion of enemy attrition in the RSAS and the requirements model.

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[1] The RSAS is a game-structured, computer-supported analytic wargaming system that has been in use at RAND and in the government for several years. Those needing access to RSAS documentation should contact Bruce Bennett in the RAND Washington office. Much of the detailed documentation is restricted to government agencies using the RSAS.

[2] CAMPAIGN-ALT is documented in Patrick Allen and Barry Wilson, *The Secondary Land Theater Model*, RAND, N-2625-NA, July 1987.

The RSAS data used to generate these results should by no means be regarded as solid. However, they reflect a variety of previous studies, as well as recent inputs from the Defense Intelligence Agency (DIA), U.S. Central Command (USCENTCOM), and other organizations, and represented the best available to us at the time of the study.

PRELIMINARY GAMING OF COMBAT IN THE PERSIAN GULF

General Outline of the Campaign

We used simple Red and Blue campaign plans in our RSAS work; they and the force levels involved reasonably matched the baseline assumptions of the requirements model. Our analyses all began with the assumption that Iraq had either left, or been expelled from, Kuwait.

Figure 10 shows the basic force laydown for the RSAS games. Iraq simultaneously invades Kuwait and Saudi Arabia with a total of 19 heavy divisions in three waves:

- On D-day, three divisions attack down each of the three axes
- On D+2, two more divisions are added to each axis
- On D+5, two divisions join the coastal attack, and one more is added to each of the other two axes.

The Iraqi air force attacks four clusters of airfields (around Kuwait City, Tabuk, Dhahran, and Riyadh) on D-day and continues these attacks until U.S. air forces are present in strength, usually around D+3. At that point, the Iraqis switch to concentrate exclusively on CAS and defensive counterair (DCA).

Blue deploys a total of nine brigades with the primary line of defense along the tapline road:[3]

- On the western axis, one Saudi brigade conducts a delaying operation from the border back to the town of Al Batin, where two brigades are dug in at the main defensive position.
- In the center, a single Saudi brigade delays back to the tapline, where once again two other brigades are deployed.

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[3] As we did in the requirements model, we assumed here that non-U.S. Blue forces were only half as effective as their equipment would suggest (e.g., 1 ED = 0.5 EED).
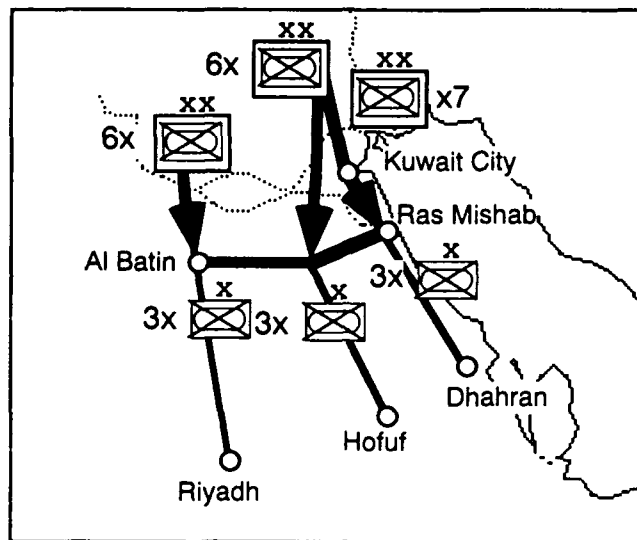
Fig. 10—Notional Campaign in Arabia

- Finally, on the coastal axis, two Kuwaiti brigades defend in the environs of Kuwait City, and a Saudi brigade digs in at Ras Mishab on the eastern end of the tapline.

Allied air forces focus primarily on CAS from the beginning of the war, with some offensive counterair (OCA) and deep interdiction carried out after U.S. air reinforcements arrrive. CAMPAIGN-ALT plays the attack helicopters of both sides in a close-support role. U.S. deployment to the region does not begin until D-day.

Observations from RSAS Gaming

Our work with the RSAS has been too limited to allow us to draw firm conclusions from it; however, we would like to make a few comments on some key issues.

First, Blue's strategy is important. Using the small forces available on D-day in the RSAS, attempts to mount a firm forward defense are risky. Few reserves are available to counter any fissure in the line, and the mass of Iraqi forces might well create one or more such cracks. The approach used in the RSAS, a delaying action back to the main defensive positions on the tapline road, maintained Blue unit integrity while buying time for allied air forces to pound the attackers. In the RSAS, attempts to hold forward positions immediately, without forcing Red to undergo several days of intensive air attack before engaging him decisively on the ground, resulted in catastrophic failures of the defense.

Moreover, Blue's limited forces cannot make more than one determined stand. That is, using the current RSAS model and terrain assumptions, game results were binary: Blue either more or less held his first defensive line, or the defense collapsed. Without U.S. or other allied reinforcement, the limited reserves available to Blue will not enable him to reconstitute a broken line. While a somewhat different result might have obtained if we had played Iraqi logistics in more detail, this and the previous observation suggests that, where possible, the defender in Arabia should trade ground for time.[4] Delaying any climactic ground battle as long as possible, while exposing the attacker's forces and logistics to concentrated allied air attack, would appear to offer substantial payoffs.

As it was in the requirements model, Blue tacair was a critical factor on the battlefield. Roughly 50 percent of all ED losses inflicted on Red in the RSAS were credited to CAS and attack helicopters.[5] This is consistent with the results generated with the simpler model.

Finally, the RSAS games suggested that any significant Iraqi maneuver capability could put Blue at risk if U.S. or other "high-quality" forces were concentrated on one approach or at one location. A single U.S. armored division could be bypassed, outflanked, or even encircled if Red forces could break through other, weaker formations on neighboring axes. The geographic flexibility of air power and airmobile forces could help alleviate this problem, but it is worrisome nonetheless. Organizing U.S. forces in separate brigades of armored cavalry regiments might provide more flexibility.

On Warning and Reinforcement

Our RSAS work included explicit modeling of strategic deployment. From the spreadsheet requirements model, we already knew the value of forces that are available early, and the RSAS games further supported this conclusion. Smaller numbers of D-day aircraft, for example, mean fewer air-to-ground kills and less disruption of enemy operations; these translate into higher Blue casualties and in all likelihood an early defeat for the defender. In both the requirements model and the RSAS, Blue typically loses quickly when it does so at all; few, if any, ground reinforcements arrive before the issue is decided. It

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[4] We realize that this recommendation ignores the possible political implications of surrendering Kuwait in this delaying operation. We did not examine in detail how many forces would be needed to prevent Iraq from overrunning Kuwait. However, Kuwait's small size and open terrain, coupled with the potential mass of an Iraqi attack, would seem to drive these requirements well beyond the range of our study of "how little is enough." A better approach would probably be to defeat the attack by exploiting superior allied flexibility, then to counterattack after receiving reinforcements.

[5] BAI in CAMPAIGN-ALT is primarily a counterlogistics mission and kills few enemy forces.

follows that if the early availability of forces is potentially critical, considerable care should be given to thinking through assumptions about strategic warning.

As events of late July and early August 1990 show, reliance on *exploiting* warning can be risky. Warning is never as unambiguous as analysts often assume it will be, and political leaders tend to respond conservatively to inconclusive indicators. Further, even if political leaders make timely decisions, deployments to the Gulf take time.

Some variety of prepositioning, either afloat or ashore, could partially offset these difficulties, but they would still leave Blue's defensive response dangerously dependent on warning. Further, we have seen repeatedly in *Desert Shield / Desert Storm* that forces are not always ready for combat as quickly as one would assume on the basis of deployment times plus nominal preparation time. Forces also may face (1) shortages of particular weapons, munitions, support items, or services, (2) a need to develop new cross-national command ties, and (3) a host of other problems. This suggests that some mix of in-place and rapid-deploying forces would be the best overall solution.

IV. CONCLUSIONS

THE BOTTOM LINE

Our analysis suggests that about 3.5 EEDs of heavy mechanized forces are needed to provide a good chance of successfully defending against an Iraqi attack on the Arabian peninsula. We believe that indigenous Saudi and Kuwaiti forces could be counted on to provide only about two of these EEDs; three or four U.S. heavy brigades could make up the difference. While this estimate is based on preliminary analysis and is subject to confirmation, it implies that a militarily useful U.S. presence in the region need not be as large as some have predicted.[1]

We also suggest that some 150-200 dedicated ground-attack aircraft be available on D-day. This requirement could be met by augmenting regional forces with three U.S. attack helicopter battalions and a wing of A-10- or A-16-class aircraft.[2]

The size of this force compares reasonably with other peacetime U.S. deployments in Europe and Korea and is smaller than the force deployed in *Desert Shield/Desert Storm*. However, two other factors need to be considered in estimating the dimensions of the entire force package.

First, both the nature of the desert environment and the likely intensity of combat mean that units forward-deployed to Arabia could require oversized support "slices." This analysis does not attempt to assign a number to the size of these elements, but they might easily double the total manpower requirements of the combat formations alone.

Second, the assumptions with which we began the study imply other force requirements. For example, the spreadsheet model assumes away Red's air force as a factor on the battlefield; making this assumption stick in reality would demand aircraft beyond those dedicated to ground support, probably many more. The model does not assume that Blue's air forces have total freedom of the skies over Baghdad, but it does assign the defender air supremacy over the FLOT and into Red's shallow rear. Whether this task requires six additional squadrons or sixteen, our analysis does not say, but several wings might be needed early on.

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[1] Our analysis does not address whether or not a "trip-wire" U.S. force in Kuwait or Saudi Arabia could have a meaningful deterrent effect. A small ground force bolstered by substantial air power would constitute much more than a classic trip wire.

[2] A U.S. armored cavalry regiment has 26 attack helicopters, according to Isby and Kamps. Thus, if four of these were deployed to meet the ground force requirement , as we suggest below, a significant amount of the needed air power would be in place as well. See David C. Isby and Charles Kamps, Jr., *Armies of NATO's Central Region*, Jane's Information Group, Ltd., Surrey, 1985, p. 363.

Also, the value of Blue's air force makes it an attractive target for the enemy, particularly if Red has large stocks of sophisticated tactical ballistic missiles (TBMs). Therefore, Blue should put in place, or be able to rapidly deploy, local defenses capable of protecting air bases and other key sites from attack by Iraqi TBMs.

COMMENTS

We have three points to make, based largely on the limited RSAS gaming done to date. First, we suggest that U.S. ground units deployed in Arabia as part of the D-day force be configured more like armored cavalry regiments or independent brigades than divisions. As noted earlier, we are concerned that U.S. forces localized in one area could be outmaneuvered by an attacker; this threat can be met in the main only by deploying forces capable of independent operations across long distances. The standard divisional support structure is inadequate to this task; something resembling a "minicorps" support structure is probably called for.

Second, the effectiveness we assumed for air forces would require a generally successful campaign to suppress enemy air defenses (SEAD), as well as the ability to operate in the presence of residual dispersed weapons such as shoulder-launched surface-to-air missiles and optically tracked air-defense artillery. Standoff munitions that outrange these systems, tactics or countermeasures that neutralize them, or munitions that allow multiple kills per pass could all contribute to maximizing air's ability to fight and survive in such an environment. Maintaining the leverage provided by Blue's air forces will require continued and expensive efforts; however, advances in areas such as those just enumerated may have higher payoffs than would the procurement of new platforms to employ old ordnance.[3]

Finally, we suggest a role for focused diplomacy and arms control in increasing the stability of the Gulf region in the wake of the recent crisis. Both technical and operational measures could effectively reduce the Iraqi threat and/or increase Blue's ability to respond effectively to renewed attack.

In the former category, the importance of air power to Blue's operations requires that Iraq not be permitted to dramatically improve its air defenses, if possible. An effective embargo on the sale of advanced surface-to-air, air-to-air, and command, control, communications, intelligence, and warning (C^3IW) systems to Baghdad might be difficult to achieve, relying as it does on an unprecedented degree of cooperation among potential suppliers. Nonetheless, most such suppliers are members of the recent coalition against

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[3] This was written before *Desert Storm,* in which U.S. air forces exploited standoff weapons and stealth aircraft with great success.

Iraq; bitter experience may teach them that it is easier, and in the long term wiser, not to sell weapons to a potential adversary than it is to destroy the weapons once they are in the enemy's hands.

Measures to reduce warning-related uncertainties could also be useful. For example, the United States and its partners could pursue a "red-line" strategy. Under such an approach, the deployment of some specified number of forces or support assets south of a certain latitude in Iraq would trigger strong responses, such as the deployment of U.S. forces to the region, mobilization of Saudi and Kuwaiti forces, and the imposition of trade sanctions against Baghdad. If all parties are confident that the necessary actions would in fact be undertaken if and when the red line is crossed, this strategy could significantly reduce the need for in-place U.S. forces in the region.

SUGGESTIONS FOR FURTHER RESEARCH

We have identified two general areas where further analysis could profitably be undertaken. First, we believe a study should be done of near-term Gulf strategy options for the United States. In particular, a close look needs to be taken at the shape of the regional balance of power in the aftermath of the recent crisis. What threats to regional order exist beside Iraq? What sizes and kinds of forces must Iraq possess in order to offset the potentially destabilizing influence of other such powers as Iran, Syria, and, potentially, Turkey? How can the United States stabilize the military balance without disrupting the equally fragile political equilibrium of the region?

Also, a more detailed follow-on to the current study is needed. Using the work reported on here as a starting point, such a study would examine the options available for ensuring a strong defensive posture in Saudi Arabia and other friendly Gulf states. We envision something of a grand trade-off study, using multiscenario, operational-level analysis to examine the relative values of:

- Air vs. ground forces
- In-place vs. afloat and/or ashore prepositioning vs. "fast-deploying" U.S.-based forces[4]
- U.S. vs. indigenous vs. nonindigenous Arab forces.

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[4] Forces reconfigured to maximize rapidly deployable firepower and/or additional lift capabilities.

The study would also encompass an assessment of operational arms control measures, such as the red-line strategy discussed above, and the implications of alternative operational strategies on force requirements.